Rogue Algae

The Mediterranean floor is being carpeted with a shaggy, aggressive invader

By JANET RALOFF

Scuba divers have long flocked to the Mediterranean's warm waters to view the colorful bustle along its seafloor. Rooted to the bottom are sponges, corals, sea fans, and anemones. While starfish and lobsters patrol corridors between their moored brethren, diverse families of plants sway in rhythm to the currents. Through it all glides a glimmering array of fish.

Over the past decade, however, these diverse communities in the northern Mediterranean have increasingly been giving sway to a novel, unusually aggressive species of algae.

Beautiful and majestic, the quick-growing invaders are carpeting the Mediterranean seafloor with a plush shag of heavily fringed fronds, many rising 30 inches or more above anchoring runners, known as stolons. They appear equally adept at colonizing rock, mud, and sand in a virtually continuous swath that can extend from the beach out to a depth of about 150 feet. Anything that can't get out of their way is smothered.

When first spotted in 1984, the alien invader covered a patch of submerged Monaco real estate no more than a square yard or so in size. By 1990, the interloper had reached France. Two years later, it was well established along the shores of the Spanish island of Majorca and, a year after that, along the coast of Sicily. By 1994, it was growing in the Croatian Adriatic.

While these algae go by the name of *Caulerpa taxifolia*, they are triple the size of any other known members of the species, observes Alexandre Meinesz, a *Caulerpa* expert at the University of Nice-Sophia Antipolis in France. The conditions under which it grows also depart dramatically from those of the species' ancestral range—the tropics and subtropics. Indeed, Meinesz notes, the only places in which a similar *Caulerpa* has been seen are several marine aquariums, including one across the beach from the water's edge where the alien's first Mediterranean sighting was documented.

Not only is the Mediterranean version of this plant incredibly tall, vigorous, and invasive, Meinesz observes, but "it's thriving where it should not even be surviving"—waters where winter temperatures would be expected to kill it. By last year, he says, his team's survey of the alien's range indicated it "was out of control."

Photos: A. Meinesz

The alien Caulerpa *can survive 10 days out of water, if it stays moist, so fragments that are caught on fishing nets and anchors can spread the algae.*

In desperation, European research teams have been investigating mechanical and chemical techniques to quell the alien algae. Unfortunately, the only strategies that have shown any promise are either too expensive or too toxic to apply on a broad scale, Meinesz reported at a small symposium in Leavenworth, Wash., 5 weeks ago.

So he and others are now actively exploring the possibility of recruiting native predators from other parts of the world in hopes of checking the alien's unrestrained spread. Although this type of biological control is becoming increasingly common in agriculture and gardening, it has never been attempted in a marine environment, observes Armand M. Kuris, an ecological parasitologist at the University of California, Santa Barbara.

An accomplished diver, Meinesz has studied *C. taxifolia* throughout its native range. Ordinarily, the species grows in isolated small clumps. There, it's never more than 10 inches high, he has found, nor present where water temperatures fall below 68°F. Yet, he has shown that the alien version of this plant can survive in the laboratory at temperatures of 50° for 3 months.

In the Mediterranean, where winter temperatures generally drop to just 55°, these algae form a dense underwater meadow. A single square yard of seafloor can be matted with 700 feet of stolons, from which emerge close to 5,000 leafy fronds.

Another feature distinguishes this Mediterranean plant: its lack of sexual reproduction.

In other locations, *C. taxifolia* disperses a shower of male and female cells that pair up and fuse to form new plants. "But over the 8 years that we have observed this *Caulerpa* in the Mediterranean, we have never seen evidence of sexual reproduction," Meinesz told SCIENCE NEWS. The only reproductive cells it releases are male, he says, fostering a suspicion that all *C. taxifolia* in the Mediterranean are clones of a single aquarium plant.

As such, the algae spread primarily through fragmentation. Like other members of this genus, each plant is a single cell—though a huge one. An alien *Caulerpa* in the Mediterranean can have a stolon more than 9 feet long, with up to 200 fronds. However, even a barely visible piece can regenerate a new plant. This has rendered all but useless any attempt to pull up the algae, either by hand or by using the underwater equivalents of plows. In fact, the plant appears to be spreading throughout the Mediterranean primarily via fragments dispersed by fishing nets and anchors.

The alien's unusual character is fueling a strong suspicion that it isn't the same species as the *C. taxifolia* long observed in other seas. It may be a hybrid or even

a new species that evolved through selective pressures in the aquarium industry. To investigate these possibilities, the Nice researchers are comparing the shape, culturing habits, and genetics of the Mediterranean plant against those of *C. taxifolia* growing elsewhere.

Meinesz is already contemplating what he might name the plant if the alien indeed proves to be a new species. Though he currently favors *C. xenogigantia*, for giant stranger, others at the Leavenworth conference suggested that he name it *C. godzilla*, as a bid to gain greater public notice of the algae's threat.

To date, "the whole history of marine pests has been one of complete fatalism," observes Kuris. Alien species "are detected, studies of their impacts are made, and then people throw up their hands and say, 'Woe is me.'"

Yet many do not embrace a vision of one alien species mowing down another, more threatening one. Andrew Cohen of the San Francisco Estuary Institute in Richmond, Calif., expresses skepticism over quickly turning to biological controls. "This stems from my sense that we are not very good at predicting how that [control] organism will act in a novel environment," he says.

It's a concern shared by Daniel Simberloff of the University of Tennessee in Knoxville. History shows that "most biocontrol projects do not work," despite the high expectations of the scientists who launched them, he says.

At the Leavenworth meeting, he described a number of instances on land where animals, once released, consumed important, desirable species rather than, or in addition to, the intended pest.

Biocontrols, though they "can be very effective," should only be tried when the targeted pest "is very unique to the ecosystem it has invaded," observes Edwin A. Theriot, who heads the aquatic ecology branch of the U.S. Army Corps of Engineers in Vicksburg, Miss. If it isn't, he notes, there can be dramatic collateral damage to nontargeted species.

Caulerpa*'s invasion transformed biologically diverse seafloor communities, like this one, into dense meadows of a single species (see cover).*

Caulerpa *predators are being recruited to attack the invader.* Oxynoe *(left) has a partial shell to protect its reproductive organs and digestive glands, while* Elysia *(right) is shell-free. With each feeding on only 5 centimeters of frond per day, Meinesz estimates that efficient control would require more than 1,000 slugs per square meter of* Caulerpa.

Meinesz believes that won't be a problem in the case of *Caulerpas* because he has chosen biocontrol candidates whose mouth structures allow them to eat only the algae. The bigger issue, he believes, is whether the control organisms will make a dent in the algae's invasion, because these predators eat at a snail's pace—literally.

He credits the idea for fighting the Mediterranean's alien algae with mollusks to a letter he received 6 years ago from Kerry B. Clark. This sea slug biologist at the Florida Institute of Technology in Melbourne had read a newspaper account of Meinesz's work and wrote to point out that many sea slugs eat only *Caulerpa*.

Meinesz didn't pursue the idea until he encountered first-hand evidence of the animals' appetite 2 years later. A *Caulerpa taxifolia* that he had imported from the Caribbean had been partially eaten during transit by 1.5-inch-long slugs—the partially shelled *Oxynoe azuropunctata* and the shell-less *Elysia subornata*. Since then, he's been studying the biology and dietary preferences of both.

Though there are related slugs in the Mediterranean that also feast exclusively on *Caulerpas*, those natives don't relish the alien *taxifolia*, Meinesz has found. Moreover, in their brief juvenile stage, the

natives float throughout the water, allowing them to travel far from where they had hatched. In contrast, the Caribbean slugs hatch on *Caulerpa* and stay there to feed. They also prefer dining on plants that are rich in various toxins, such as caulerpanyne—and no *Caulerpa* is a richer source of these toxins than the Mediterranean's alien algae.

The slugs use the ingested toxins to make themselves unappealing to would-be predators. The same toxins help explain why fish and other seaweed feeders find the alien *Caulerpa* unappetizing.

Because the Caribbean slugs probably won't survive the Mediterranean's winter temperatures, they might make a "reversible" control candidate, observes Cohen. If they show an unacceptable preference for any of the Mediterranean's three native species of *Caulerpa*—or appear capable of edging out the native mollusks that feed on them—the introduced slugs could be allowed to die out over the winter, he says.

But if they work as anticipated, Clark says he can supply Floridian colonies of both species that are far more cold-tolerant. "These could be released as a permanent [self-perpetuating] control."

Kathe R. Jensen, a sea-slug biologist with the Zoological Museum in Copenhagen, worries about a possible complication. A less aggressive alien *Caulerpa—C. racemosa*—has also invaded the Mediterranean. "That species seems to be preferred by most of the [slugs] that feed on *Caulerpa*," she told SCIENCE NEWS. So she worries that any alien slugs released against the aggressive algae "will eventually migrate to *racemosa* and ignore the *taxifolia* that is giving all the problems."

Clark cites another concern. Because the slugs don't actually eat *Caulerpa*, but merely suck the saplike juice from its fronds, "lots of the plant survives to regenerate. So the best you can hope for is an equilibrium in which the alga is there but not as a pest."

Few marine invaders appear as well suited to become a first target for marine biocontrols as this *Caulerpa*, Kuris told SCIENCE NEWS. Indeed, he argues, the decision to unleash slugs against the algae is quickly moving "from a question of science to one of politics."

Because inaction allows the alien "to continue to extirpate large numbers of invertebrates and other algae," he says, policy makers have to decide if that's preferable to taking a risk with introduced snails.

In this case, agrees *Caulerpa* expert James N. Norris of the Smithsonian's National Museum of Natural History in Washington, D.C., "I would go so far as to say that biocontrol is an option that has to be seriously considered."

U.S. waters, so far, have not been infiltrated by the new form of *Caulerpa*. It has been observed in an aquarium in Honolulu, however, and there are no restrictions on its distribution through the aquarium trade. Norris says, "We need to call attention on a national level—to whatever powers that be—that this plant should not be imported. We definitely don't want it in Florida, the Gulf of Mexico, or anywhere else."

Cohen agrees, and he is currently drafting a letter, to be endorsed by marine scientists, that will highlight this algal threat. It will accompany a formal request that the United States prohibit the sale, possession, or transport of the alien species.

Members of a United Nations workshop on invasive Mediterranean *Caulerpas* made much the same recommendation 2 months ago. Citing the 1992 international Convention on Biological Diversity—which asks ratifying nations "to regulate the intentional or accidental introduction of non-indigenous species"—the members advised that European nations prohibit the aquarium trade or anyone else from selling or housing the lovely scourge. □

Biocontrols may not work for jellies

One of the more devastating alien invasions in the past 20 years has been the arrival of a gelatinous American import in the Black Sea and adjacent waterways. First identified in 1982, populations of these comb jellies (*Mnemiopsis leidyi*) soon swelled to dramatic proportions, contributing to the 1989 crash of the Black Sea's largest surviving fishery: anchovies. That year, the landed catch fell by more than two-thirds, to less than 100,000 metric tons.

Since then, anchovy stocks have begun rebounding—but only because most of the Russian fleet has been too poor to fish, according to Richard Harbison of the Woods Hole (Mass.) Oceanographic Institute. For years, the Russians and Turks had shared the anchovy stocks. "With *Mnemiopsis* coming in as a third, equal competitor," he said, "the fishery became unsustainable."

Lacking stinging tentacles, *Mnemiopsis* is not a true jellyfish. Instead, it belongs to the *Ctenophora*, a family of planktonic animals that depend on tiny cilia to paddle feebly about. Native to salty and brackish coastal areas from Massachusetts to Argentina, the animals glide through the water like graceful, palm-size, luminescent vacuums. Anything smaller that is unfortunate enough to bump into the sticky, mucus-lined lobes near their mouths is devoured.

Though *Mnemiopsis* can eat fish eggs and larvae, it's unlikely that such direct predation accounted for the anchovy crash, argues Jennifer E. Purcell of the University of Maryland in Cambridge. An expert on *Mnemiopsis* feeding and reproduction in the Chesapeake Bay, she suspects the jellies instead cut the anchovy stock by eating most of its food.

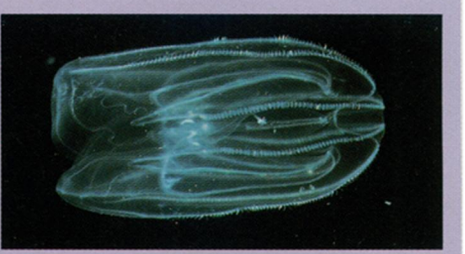
Moreover, points out Tamara Shiganova of the Russian Academy of Sciences Shirshov Institute of Oceanology in Moscow, the 1988 commercial anchovy catch was excessive, pulling out some 80 percent of the available fish. With such a depleted fishery, the burgeoning jellies had little competition while feasting on the base of the area's food chain.

Though no one knows how these voracious jellies entered the Black Sea, ecologists suspect they were spilled along with ballast water dumped by ships returning from American ports.

The Black Sea contains none of *Mnemiopsis'* natural predators, so when the waters warm and food becomes plentiful, the invasive colonizers exhibit blooms. In late summer, Shiganova says, fishermen raise nets clogged by the mucuslike remains of *Mnemiopsis'* net-damaged bodies.

At a recent meeting in Leavenworth, Wash., on controlling established populations of alien marine species, dozens of ecologists debated the relative merits of trying to collect the jellies' natural predators and reunite them with *Mnemiopsis* in the Black Sea. The most likely candidates for biocontrol include *Baroë*, another ctenophore that eats only comb jellies, and the butterfish, a fish of low commercial appeal with a fairly catholic diet that includes *Mnemiopsis*.

Despite near unanimity that the Black Sea is already heavily polluted, greatly overfished, and outrageously perturbed by the recent introduction of *Mnemiopsis*, most scientists were reluctant to push for bringing in more aliens. They fear that species introduced as biocontrols might move through the Bosporus, a strait in Turkey, and into the Mediterranean—competing with its native species. —*J.R.*



R. Harbison/WHOI

During the peak of its 1998 bloom, Black Sea populations of this palm-size jelly may have equaled the mass of the region's primary commercial catch, anchovies.